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PRODUCTION MEASUREMENT OF FUZE COMPONENTS UNDER DYNAMIC STRESS.(U)
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LEVEL II

SIXTH QUARTERLY REPORT

PRODUCTION MEASUREMENT OF FUZE COMPONENTS
UNDER DYNAMIC STRESS

11 AUGUST 1977 - 10 NOVEMBER 1977

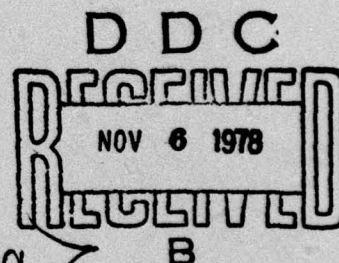
CONTRACT NUMBER DAAB07-76-C-0032

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U.S. ARMY ELECTRONICS COMMAND
PROCUREMENT AND PRODUCTION DIRECTORATE
COMMUNICATION SYSTEMS PROCUREMENT BRANCH
FORT MONMOUTH, NEW JERSEY 07703

New CONTRACTOR *H10925*
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PRODUCTION MEASUREMENT OF FUZE COMPONENTS
UNDER DYNAMIC STRESS.

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SIXTH QUARTERLY REPORT. no. 6

11 AUGUST 1977 - 10 NOVEMBER 1977

14 REC-
DOCUMENT NO. 78-017

OBJECT OF STUDY: DEVELOPMENT OF A COMPUTER
CONTROLLED AUTOMATIC TESTER,
CAPABLE OF TESTING AND TRIM-
MING THICK FILM ADJUSTMENT
CIRCUITS AT THE RATE OF
3,000/HOUR

15

CONTRACT NUMBER DAAB07-76-C-0032

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PREPARED BY

RICHARD F. DE MATTOS
ROBERT BLAU

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ABSTRACT

During the sixth quarter, an additional 32k of memory and a more sophisticated software package were added to the computer; check-out is in progress. Input/Output (I/O) routines are being added to the present amplifier's real-time program.

Ten of sixty-three newly delivered "formed antennas" were assembled into oscillators, and preliminary tests were conducted on the modified oscillator design.

All radio frequency (RF) Modulator major components and sub-assemblies were delivered. The sensitivity-capacitance prediction programs have been completed, but have not yet been tested.

Program equipment and personnel were moved to a new facility.

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CONTENTS

<u>Section</u>	<u>Page</u>
ABSTRACT	i
1 PURPOSE	1
2 NARRATIVE AND DATA	2
2.1 Introduction	2
2.2 Redesigned Fuze	2
2.3 Test Signal Subsystem	8
2.4 Mechanical Design	9
2.5 Programming and Computer Hardware	10
3 CONCLUSION	13
4 PROGRAM FOR NEXT QUARTER	14
5 PERSONNEL	15
 <u>APPENDIX</u>	
A Sensitivity-Capacitance Prediction Program	
 <u>FIGURE</u>	
1 Oscillator, Simplified Schematic	4
2 Trimmable Capacitor Pattern (Binary Ratio)	5

1. PURPOSE

The purpose of this program is to develop a dynamic test and correction system, capable of high speed operation, for electronic assemblies. The circuits selected for verification under this contract are the oscillator and amplifier assemblies of the M732 fuze. The contract requires that 3,000 units of each assembly be delivered, of which 2,900 have been trimmed to meet the specifications. The required test rate is 3,000 an hour.

2. NARRATIVE AND DATA

2.1 INTRODUCTION

During the sixth quarter, the computer system was upgraded by increasing its memory capability by 32k and adding a more sophisticated software package. I/O routines are being added to the amplifier real-time program and modifications incorporated as a result of the new system and to reduce test time. The altered computing system is being rechecked to assure proper functioning per specifications.

Ten of the sixty-three newly delivered "Formed Antennas" were assembled into oscillators and preliminary tests performed to electrically check design modifications made to the original Harry Diamond Laboratories (HDL) oscillators. Indications are that some added changes are still required to make the modified design electrically similar to its HDL counterpart.

All RF Modulator major components and sub-assemblies have been delivered. The sensitivity-capacitance prediction programs have been completed but not tested.

2.2 REDESIGNED FUZE

2.2.1 Fuze Prototype Fabrication

Amplifiers - Preliminary laser cutting of prototype amplifier boards began during the reporting period. Progress in these latter areas was slowed as a result of problems encountered in computer software and hardware (see Section 2.5) and an extended down time period when the program group was moved to a new facility.

The amplifier printed circuit board (Dwg. 06006411) has been released for purchase of production quantities. Delivery is scheduled for January 1978. R9 installation will follow after finalization of the thick film resistor design.

A systematic evaluation of R9 dynamic resistance variations after laser cutting was postponed because of computer and laser problems. Selection of a final R9 design will be based on the outcome of tests.

Oscillators-Sixty-three Formed Antennas (Dwg. 06006416) were delivered to Lockheed at the end of the last quarter to replace defective prototype units previously received. Ten oscillator assemblies (Dwg. 06006415) were completed from this group and preliminary sensitivity, detector voltage and frequency measurements were made so that the modified oscillator design could be compared to the original HDL units. (See Figure 1 for a simplified schematic of the original oscillator). The chip capacitor design described in the fifth quarterly report⁽¹⁾ was installed in these oscillator assemblies with chip capacitors C21 and C22 (Figure 2) cut along Trim Path I so that a one-to-one comparison could be made to the original units. (The HDL approach added capacity, C21 and C22, to the main circuit; the modified oscillators removes capacity). These tests began prior to relocation and were suspended afterwards because of the temporary lack of a facility clearance until the last third of the reporting period. Laser down time also contributed to some delay. Preliminary results, however, indicate that the redesigned assembly sensitivities are from 50 to 70 percent higher than the original oscillators. Measurements of antenna circuit capacitance (C20 and C23) deviated from the original test models in part from slightly different printed circuit board thicknesses and in part as a result of different C23 plate areas. Continued testing

⁽¹⁾ Fifth Quarterly Report, Production Measurement of Fuze Components Under Dynamic Stress, 11 May 1977 to 10 August 1977. Contract Number DAAB07-76-0032.

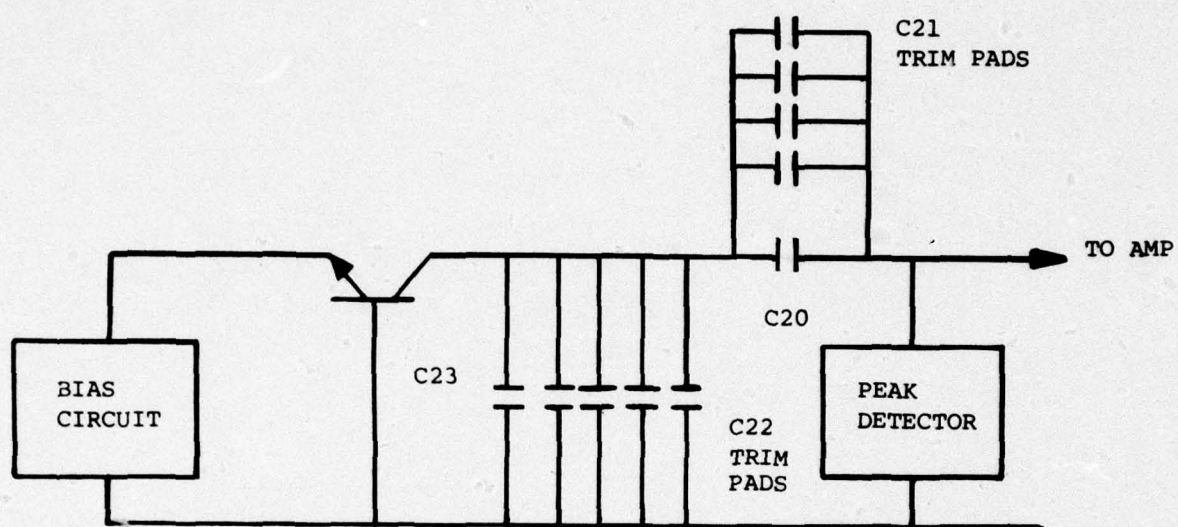
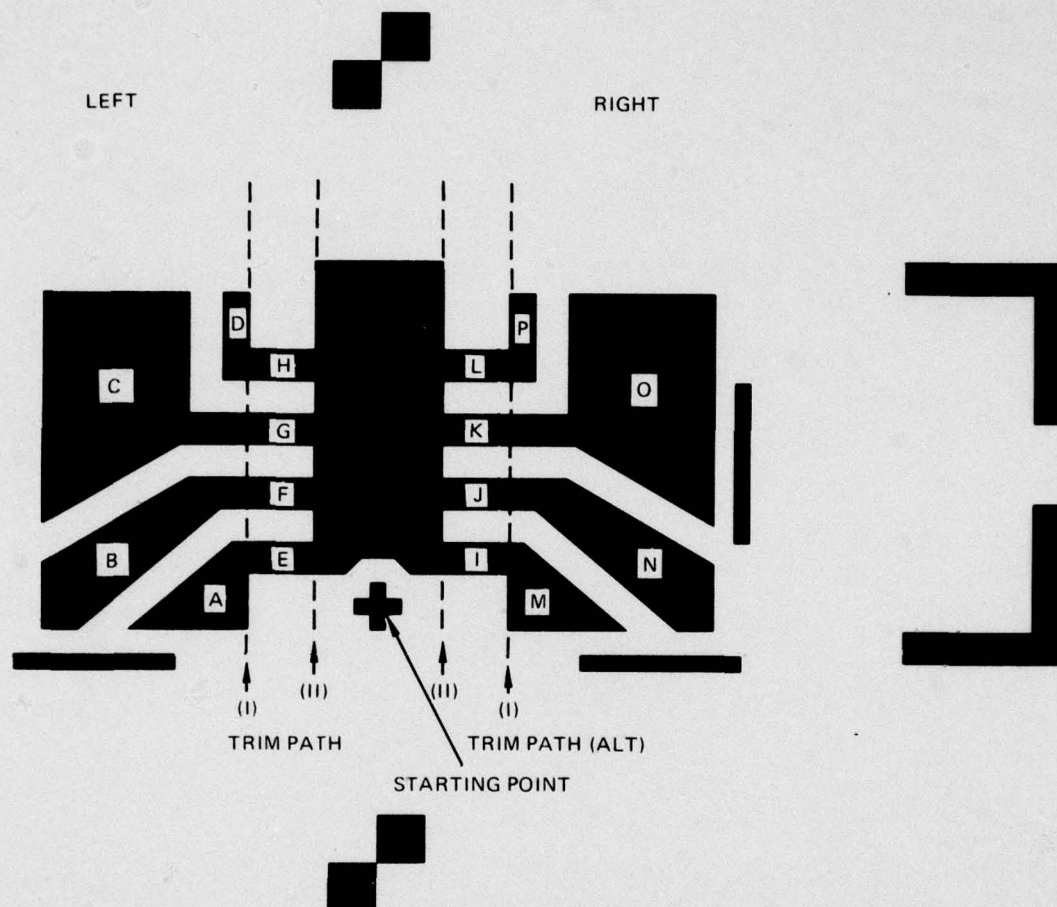
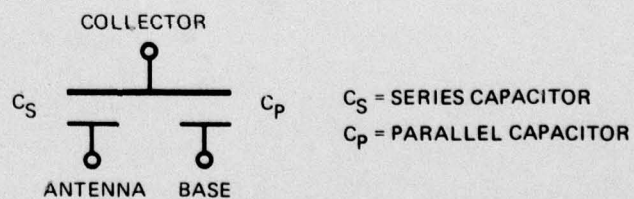


Figure 1. Oscillator, Simplified Schematic



A.) UPPER PLATE ARTWORK



B.) ELECTRICAL SCHEMATIC

Figure 2. Trimmable Capacitor Pattern (Binary Ratio)

during the next two quarters will complete this investigation. It appears, at the time of this writing, that some modification to C23 plate area will have to be made before the antenna can be finalized. This will be accomplished during the next two reporting periods.

2.2.2 Oscillator Chip Capacitor

The investigation of circuit proximity effects on binary capacitance values initiated in the previous quarter was postponed. A modified version of the initial binary capacitance design will be constructed based upon previously derived data. It was felt that predicted errors resulting from these perturbations will be far smaller than the inconsistencies introduced by variations in transistor, diode and antenna printed circuit board parameters.

This decision may be viewed from another point of departure by assuming the availability of perfectly accurate binary value capacitances in place of the more realistic, slightly inaccurate versions. Even if perfect binary capacitors are available, the ability to predict precise changes in sensitivity is still questionable.

The prediction of changes in detector sensitivity with $(C20 + C21)$ and $(C22 + C23)$ depends upon the existence of a universal sensitivity-capacitance curve applicable to all oscillator assemblies. This is only approximately true. Experiments performed on test oscillators have indicated that a unique curve does not exist and that prediction inaccuracies resulting from the lack of a universal curve outweigh the inconsistencies resulting from C21 and C22 capacitance variations.

It is presently felt that additional experiments can be conducted after the laser-computer interface, modified chip capacitor and prototype oscillators have been finalized. Implementation of these experiments can be viewed more as "fine tuning" the prediction criterion rather than determining the prediction curves themselves. It should be noted that the computer programs

described in Section 2.2.3 and in Appendix A are relatively good now, especially as a "First Try" approximation. Refining the binary step capacity accuracy at this point in time is therefore considered unnecessary.

2.2.3 Sensitivity-Capacitance Prediction Programs

During this quarter, a computer program was completed for trimming oscillator capacitances to achieve the desired sensitivity (see Appendix A of this report for a listing of this program). The new program differs from previous programs in that information on the results of each capacitive trim of a given oscillator is fed back to the computer to allow the computer to modify its predictions for subsequent trims. This feature was not present before because the programs were used on production runs in which there was no serialization and therefore no data traceability. Now these programs have been combined and modified specifically for the ECOM tester. A detailed description of the mathematical basis of a non-linear oscillator model is given in Appendix A of the second quarterly report⁽²⁾. Two computer programs were written at that time for trimming production fuzes to a desired value of sensitivity. The first was based on this non-linear model, while the second was based on an extremely simple linear algorithm. These computer programs were used to trim approximately 1000 production fuzes with fairly good results (see Section 2.9 of the fourth quarterly report⁽³⁾). Both programs were successful in bringing all the oscillators within the desired sensitivity specifications after three cuts. The non-linear program exhibited better results in first cut success ratio. The disadvantage of the non-linear program is that it consumes appreciably more process time than the linear program.

(2) Second Quarterly Report covering 11 August 1976 to 10 November 1976.

(3) Fourth Quarterly Report covering 11 February 1977 to 10 May 1977.

Because the oscillator's sensitivity versus capacitance behavior is highly non-linear, non-monotonic and varies considerably from oscillator to oscillator, it was felt that the linear model by itself might not be adequate to trim all of the ECOM production fuzes. Accordingly, a program was written which uses the non-linear model for the first cut and then if additional trimming is required, assumes a linear relationship from that point on. The first step in using the program is calibration of the test chamber. This is accomplished by measuring the sensitivity of two currently built oscillator assemblies under various combinations of series and parallel capacitive pads. The results are fed into a calibration program (called CAL-21) which calculates constants required by the main program. The calibration program is run just once, prior to the production trimming of any fuzes. The output of the calibration program is placed into a file in the computer, which is then read by the main non-linear program. The latter accepts information obtained by the first measurements, performs its non-linear calculation, issues instructions for capacitor trimming, retests and accepts the results of the trimming. If the sensitivity is not within $\pm 1/2$ percent of the desired value, it switches to the linear mode, and issues instructions for additional trimmings until the unit is within specification.

This program has not yet been used to trim fuzes. This will be done sometime during the next two reporting periods. Results will be reported at that time.

2.3 TEST SIGNAL SUBSYSTEM

The effort expended during this quarter was re-oriented toward completing the amplifier board interface since programming for exercising these units is closer to completion than with the oscillators. As a result, very little added effort was expended on the RF Modulator and signal processing circuitry.

2.3.1 RF Modulator Status

2.3.1.1 Purchased Components. - All major purchased items and sub-systems have been delivered. Chassis fabrication, assembly and test have not as yet begun.

2.3.1.2 In House Designs. - All major components and sub-units described in the fifth quarterly report have been purchased and delivered. Breadboarding of the designs described however, have not been completed or tested.

2.3.2 Amplifier Board Signal Processing

A description of the amplifier board signal circuit requirements and functions are described in the fifth quarterly report. Progress in this area has been limited to a detailed review of computer input-output requirements as it applies to testing amplifier boards and reviewing the proposed system cabling for accuracy and completeness.

2.4 MECHANICAL DESIGN

Changes were made to the amplifier printed circuit board (Dwg. 06006411), its artwork and masking artwork to facilitate component insertion, and to obtain a better contact between the amplifier assembly and tester signal probes.

Some of the streets on the amplifier printed circuit board were re-routed to eliminate potential overlapping of holes and streets as a result of positioning tolerances. Twelve test pads were added to the printed circuit board to increase the contact area to the amplifier fixture probes. New test probes with a different form factor are being considered for use in the final system. This is necessary as the present sampling probes give intermittent results.

2.5 PROGRAMMING AND COMPUTER HARDWARE

The main effort in this quarter focussed on upgrading the computing system with an additional 32k of memory and a more complex operating and control system (i.e. HP RTE-III). This task was accomplished by manufacturer and LEC personnel.

During this time, the actual real-time amplifier program was being debugged and I/O routines added to the original program.

Once the equipment was moved and again operational, a familiarization and checkout period was needed to assure that the system was functioning per specifications. Several problems were encountered at this time in the modified system requiring re-incorporation of the expanded system and a complete hardware checkout. This was accomplished towards the end of the reporting period with final checkout under way by its end.

2.5.1 Computer Memory Expansion

In order to expand the memory capability of the 21MX computer, two additional 16k memory cards (HP #1318MA 16k memory module), one DMS (Dynamic Mapping System) and HP #1231-6000, and one RTE III Software package (vendor part number 92060B) had to be configured into the operating system.

The two memory cards required changes to the XW1 jumper strip located on the card itself. The cards are supplied by the manufacturer with all the jumpers in. The changes made to the memory card jumpers are given in the table below:

MEMORY MODULE NO.	XW1 JUMPERS						
	A (2^0)	B (2^1)	C (2^2)	D (2^3)	E (2^4)	F (2^5)	G
1	IN	OUT	IN	IN	IN	IN	OUT
2	OUT	OUT	IN	IN	IN	IN	OUT

The jumper changes are based on a binary code which tells the operating system how many cards constitute the memory and the address code used by the system to address a particular portion of memory.

2.5.2 Computer Problems

The additional 32k of memory added to the system could not be addressed under RTE III control. The problem was that the manufacturer had configured the DMS for their newer model computer - 21MX E-Series Computer (2109/2113). This program uses the 21MX M-Series Computer which has a slower instruction cycle and memory access time than the 21MX-E Computer. The computer compatibility was solved by soldering card jumper W1 to make the card compatible to our system. Making this change did not totally solve the original problem of accessing the added 32k of memory. Analysis of the problem showed that when the system tried to address the additional memory, control was not transferred to the expanded memory but stayed in the original 32k of memory. A wiring change in card jumper W4 from position A to B allowed the system to access the added memory and return to the original 32k of memory upon completion of the program in the extended memory.

A summary of the changes to the DMS card is provided in the following table:

JUMPER	DESCRIPTION
W1	Plug in Jumper: Selects computer compatibility as follows: W1 = A = 21MX-M Series Computer (2108/2112) W1 = B = 21MX-E Series Computer (2109/2113)
	Initial Status: W1 = A Final Status: W1 = B
W4	Hardwired Jumper: Reset memory expansion module (DMS) W4 = A = Memory control remains in system MAP W4 = B = Memory control returns to same MAP in use prior to interrupt to memory system.
	Initial Status: W4 = A Final Status: W4 = B

2.6 LASER PROBLEMS

Recurring difficulties were encountered throughout the program in the Laser cutting system. Two specific problems were noted;

- a) Insufficient cutting power and,
- b) Insufficient lighting for adequate TV camera monitoring.

Of the two, the lack of laser cutting power was the most serious. The laser optical system was re-aligned periodically to provide sufficient power to cut thick film resistors and chip capacitors. Invariably, "de-tuning" would occur within a few weeks. The problem was ultimately found after repeated re-alignments. One of the prisms in the optical system used to position the laser energy over the work piece was appropriately wedged in its mount but not cemented in place. After alignment, any table vibration or movement would shift this prism sufficiently to mis-align the infra-red optical system. The result; laser output power below acceptable limits.

The second problem was improved by replacing the TV camera with a more sensitive unit.

3. CONCLUSION

Activities and objectives of the sixth quarter are summarized as follows:

- . The system computer was upgraded by an additional 32k of memory and a new expanded software package. Checkout is in progress.
- . The amplifier real-time program was modified to reflect the new expanded memory and software. I/O routines are being added and debugged.
- . Preliminary tests were performed on ten oscillator assemblies.
- . Oscillator sensitivity-capacitance prediction programs were completed but not tested.
- . All major sub-system hardware and components associated with the RF Modulator have been delivered.
- . Fabrication and test of the RF Modulator and signal processing subsystems were halted because of computer problems and upgrading activities.
- . All program activities and equipment were moved to a new facility.

4. PROGRAM FOR NEXT QUARTER

During the next reporting period, the following activities are planned;

- . Complete checkout of the upgraded computer software and hardware.
- . The real-time amplifier test program will be debugged and tested with prototype amplifiers.
- . The thick film R9 resistor design will be finalized.
- . Production amplifiers (excluding R9) will be assembled.
- . Oscillator design will be finalized.
- . The oscillator test signal subsystem will be built.

5. PERSONNEL

During this reporting period, the following personnel worked on this program for the number of hours indicated.

<u>NAME</u>	<u>PROGRAM FUNCTION</u>	<u>HOURS</u>
A.J. Eisenberger	Program Manager	6
R.F. DeMattos	Tester RF and Fuze	304
S. Conston	Digital Components	2
U.Z. Escoli	Mechanical Design	68
	Draftsmen, Machinist, Technician	441
	Technical Publications	156

APPENDIX A

NLM-21 in conjunction with CAL-21 provide the analytic basis for calculating the change of capacitance (series or shunt) needed to shift UUT oscillator sensitivity to a specified value.

The calibration program, CAL-21, takes "raw" oscillator data (i.e., Detector voltage, sensitivity and operating frequency) from two representative units, calculates a critical transistor parameter (VEB/Z12) and places the result into a separate (B-file) for use by NLM-21.

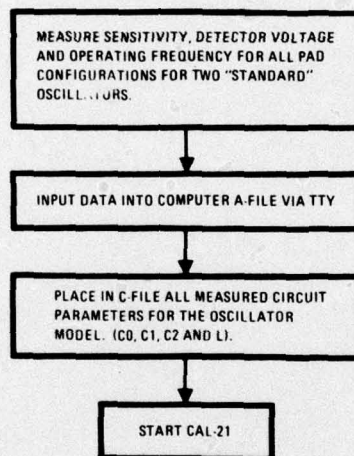
The working program, NLM-21, estimates the necessary change in individual UUT series or shunt capacitance as based on measured and desired value of sensitivity.

Three software files are required by CAL-21 and NLM-21. They are:

<u>FILE</u>	<u>DATA</u>
A	1) All standard pad configurations 2) Sensitivity, Detector Voltage, and Operating Frequency data.
B	(VEB/Z12) versus pad configuration for all possible configurations.
C	Measured circuit parameters for the oscillator model.

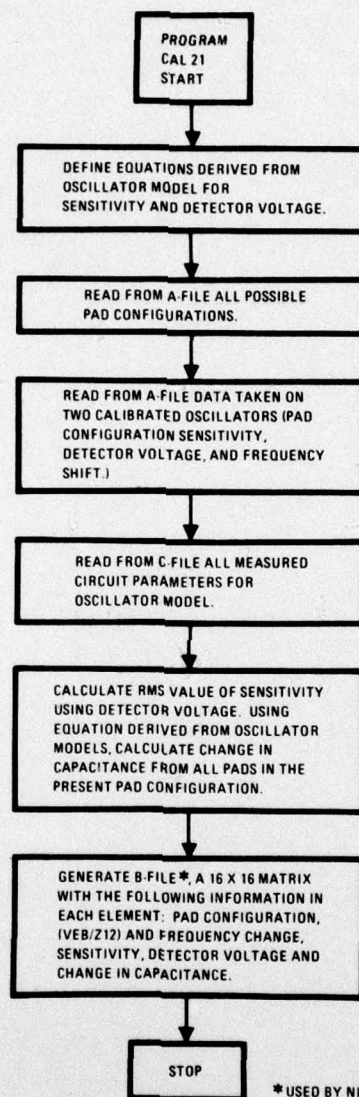
Figure A-1 is a flow graph of the preliminary data gathering and filing sequence needed prior to using CAL-21 or NLM-21.

Figure A-2 and A-3 are flow graphs of CAL-21 and NLM-21 respectively. Listings of these programs appear after these figures.



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Figure A-1. Preliminary Data Measurement and Filing



*USED BY NLM 21

Figure A-2. Flow Chart For Program CAL-21

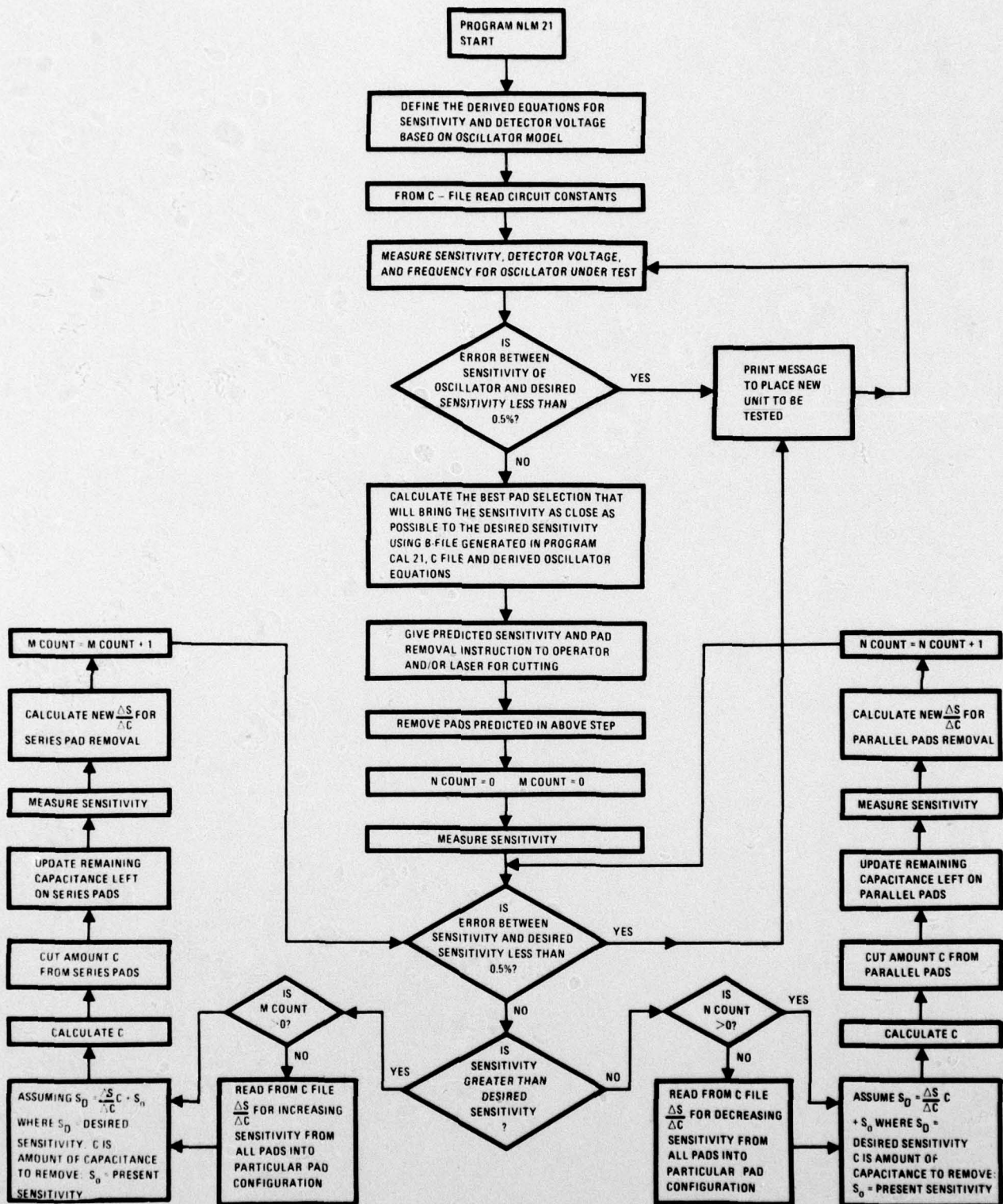


Figure A-3. Flow Chart For Program NLM-21

CAL21 & NLM-21 LISTING

```

C*   PROGRAM CAL21
C*
C*****CAL21 GENERATES THE CONSTANTS A(K,L),B(K,L),
C*   QMUA(K,L),QMUB(K,L),QNUA(K,L),QNUB(K,L) FOR
C*   USE IN NLM21
C*
C*****THE SUBSCRIPTS K,L REFER TO PADS REMOVED
C*   ACCORDING TO THE FOLLOWING SCHEME:
C*           C(SERIES)=- (K-1)*DELTAC
C*           C(PARALLEL)=- (L-1)*DELTAC
C*
C*
FILE 5=AFILE,UNIT=DISKPACK,BLOCKING=30,RECORD=14
FILE 6=BFILE,UNIT=DISK,RECORD=14,BLOCKING=30,AREA=900
FILE 8=CFILE,UNIT=DISKPACK,BLOCKING=30,RECORD=14
C*
C*****AFILE CONTAINS:
C*
C*   FIRST, A LOOKUP TABLE FOR PAD SELECTION AS FOLLOWS:
C*
C*           BINARY CODE           CONFIG. NO. (K)           IC(K)
C*
C*           0000                   1                       9
C*           0001                   2                       1
C*           0010                   3                       1
C*           0011                   4                      12
C*           0100                   5                       3
C*           0101                   6                      13
C*           0110                   7                      23
C*           0111                   8                     123
C*           1000                   9                       4
C*           1001                  10                      14
C*           1010                  11                      24
C*           1011                  12                     124
C*           1100                  13                      34
C*           1101                  14                     134
C*           1110                  15                     234
C*           1111                  16                     1234
C*
C*****SECOND, IT CONTAINS THE MEASURED VALUES FOR THE TWO
C*   CALIBRATION UNITS IN THE FOLLOWING FORM:
C*
C*           I,IC(K),IC(L),SENS,VDC,FREQ
C*
C*
C*   I IS THE SERIAL NO. AND HAS THE VALUE 1 OR 2
C*
C*   IMPLICIT COMPLEX (Z)
C*   DIMENSION ICINV(1248),IC(16),
C*   *           A(16,16),B(16,16),

```



```

*          QMUA(16,16),QMUB(16,16),
*          QNUA(16,16),QNUB(16,16),
*          SM(2,16,16),VM(2,16,16),FM(2,16,16),
*          RMU(2,16,16),RVU(2,16,16)
ZR(X)=CMPLX(X,0)
ZI(X)=CMPLX(0,X)
ZC(X,Y)=CMPLX(X,Y)
ZA(X,YY)=X*CEXP(ZI(YY))
RNUM(P)=P*COS(OE)+RW*COS(OW)-R
RDEN(P)=P*COS(OE)+RW*COS(OW)+R
XNUM(P,T)=P*SIN(OE)+RW*SIN(OW)-T*BETA*RL0+1./T/ALPHA/C0
XDEN(P,T)=P*SIN(OE)+RW*SIN(OW)+T*BETA*RL0-1./T/ALPHA/C
RR(X)=31171.*7339**2*X**4/3.0E+10**4
O(Q,Y)=-2.*SS*Q/3.0E+10+Y*PI
ZU=ZR(1)
ZJ=ZI(1)

C*
C*****SET IC,ICINV, AND READ MEASURED VALUE
C*
      READ(5,/) (IC(I),I=1,16)
      DO 5 I=1,16
        ICINV(IC(I))=I
5      CONTINUE
10     READ(5,/,END=20)I,KI,LI,S,V,F
        F=(F1+F)*1.0E+06
        K=ICINV(KI)
        L=ICINV(LI)
        SM(I,K,L)=S
        VM(I,K,L)=V
        FM(I,K,L)=F
        GO TO 10

C*
C*****FREQUENCY ALGORITHM
C*
20     DO 100 K=1,16
        DO 100L=1,16
          IF(FM(1,K,L).EQ.0)GO TO 100
          IF(FM(2,K,L).EQ.0) GO TO 100
          A(K,L)=(FM(1,K,L)-FM(2,K,L))/(FM(1,1,1)-FM(2,1,1))
          B(K,L)=FM(1,K,L)-A(K,L)*FM(1,1,1)
          WRITE(6,(4/))K,L,A(K,L),B(K,L)
100    CONTINUE
        WRITE(6,/)LZ,LZ,RLZ,RLZ

C*
C*****SENSITIVITY CALCULATION*
C*
      PI=4.*ATAN(1.)
      SXX=SQRT(2.)

C*
C*****READ CKT CONSTANTS
C*
      READ(8,/)SD,A1,A2
      READ(8,/)RE,RW
      READ(8,/)YE,YW
      READ(8,/)ALPHA,BETA

```

```

      READ(8,/)VB,SS,RS,RL0
      READ(8,/)C0,C1,C2,DEL TAC
C*
C*****C1,C2 ARE CAP VALUES IN PFS WITH ALL PADS IN
C*
      RL0=BETA*RL0*1.0E-09
      C0=ALPHA*C0*1.0E-12
      C1=ALPHA*C1*1.0E-12
      C2=ALPHA*C2*1.0E-12
      DEL TAC=ALPHA*DEL TAC*1.0E-12
C*
C*****START PRINCIPAL DO; CALCULATION OF RMU,RNU
      DO 200 I=1,2
      DO 200 K=1,16
      DO 200 L=1,16
      IF(A(K,L).EQ.0) GO TO 200
      VM0=VM(I,K,L)-VB
      VMMA=VM0+SXX*SM(I,K,L)
      VMMIN=VM0-SXX*SM(I,K,L)
      G=2.*PI*FM(I,K,L)
      CS=C1-(K-1)*DEL TAC
      CP=C2-(L-1)*DEL TAC
      C=1./(1./C0+1./CS+1./CP)
      OE=O(G,YE)
      OW=O(G,YW)
      R=RR(FM(I,K,L))
      ZNUM=ZC(RNUM(0),XNUM(0,G))
      ZDEN=ZC(RDEN(0),XDEN(0,G))
      RMU(I,K,L)=VMMA*G*CP*CABS(ZDEN/ZNUM)
      ZNUM=ZC(RNUM(RE),XNUM(RE,G))
      ZDEN=ZC(RDEN(RE),XDEN(RE,G))
      RNU(I,K,L)=VMMIN*G*CP*CABS(ZDEN/ZNUM)
200  CONTINUE
C*
C*****CALCULATION OF THE Q'S
C*
      DO 300 K=1,16
      DO 300 L=1,16
      QMUA(K,L)=(RMU(1,K,L)-RMU(2,K,L))/(RMU(1,1,1)-RMU(2,1,1))
      QMUB(K,L)=RMU(1,K,L)-QMUA(K,L)*RMU(1,1,1)
      QNUA(K,L)=(RNU(1,K,L)-RNU(2,K,L))/(RNU(1,1,1)-RNU(2,1,1))
      QNUB(K,L)=RNU(1,K,L)-QNUA(K,L)*RNU(1,1,1)
      WRITE(6,(4)/)K,L,QMUA(K,L),QMUB(K,L)
      WRITE(6,(2)/)QNUA(K,L),QNUB(K,L)
300  CONTINUE
      LOCK 6
      STOP
      END

```



```

C*   PROGRAM NLM21
C*
FILE  4=AFILE, UNIT=DISKPACK, BLOCKING=30, RECORD=14
FILE  7=BFILE, UNIT=DISKPACK, BLOCKING=30, RECORD=14
FILE  8=CFILE, UNIT=DISKPACK, BLOCKING=30, RECORD=14
C*
C*
C*****AFILE CONTAINS THE MEASURED DATA FROM 2
C*           CALIBRATION UNITS AND IS READ BY CAL21
C*****BFILE CONTAINS THE CONSTANTS FOR THE SENSITIVITY
C*           ALGORITHM(QMU,QNU) AND THE FREQUENCY ALGORITHM
C*           (A,B). IT IS GENERATED BY CAL21
C*****CFILE CONTAINS THE CIRCUIT CONSTANTS ; THESE WERE
C*           DERIVED FROM NLM20
      IMPLICIT COMPLEX (Z)
      DIMENSION ICINV(1234),IC(16),
*           A(16,16),B(16,16),QMUA(16,16),QMUB(16,16),
*           QNUA(16,16),QNUB(16,16)
      ZR(X)=CMPLX(X,0)
      ZI(X)=CMPLX(0,X)
      ZC(X,Y)=CMPLX(X,Y)
      ZA(X,YY)=X*CEXP(ZI(YY))
      RNUM(P)=P*COS(OE)+RW*COS(OW)-R
      RDEN(P)=P*COS(OE)+RW*COS(OW)+R
      XNUM(P,T)=P*SIN(OE)+RW*SIN(OW)-T*BETA*RL0+1./T/ALPHA/C0
      XDEN(P,T)=P*SIN(OE)+RW*SIN(OW)+T*BETA*RL0-1./T/ALPHA/C
      ZNUM(U,V)=ZC(RNUM(U),XNUM(U,V))
      ZDEN(U,V)=ZC(RDEN(U),XDEN(U,V))
      RR(X)=31171.*7339**2*X**4/3.0E+10**4
      O(Q,Y)=-2.*SS*Q/3.0E+10+Y*PI
      ZU=ZR(1)
      ZJ=ZI(1)

C*
C*****SET CIRCUIT CONSTANTS
C*
      PI=4.*ATAN(1.)
      SXX=SQRT(2.)
      READ(4,/) (IC(I),I=1,16)
      DO 4 I=1,16
      ICINV(IC(I))=1
4      CONTINUE
      READ(8,/) SD,A1,A2
      READ(8,/) RE,RW
      READ(8,/) YE,YW
      READ(8,/) ALPHA,BETA
      READ(8,/) VB,SS,RS,RL0
      READ(8,/) C0,C1,C2,DEL TAC
      REWIND 8

C*
C*****C1,C2 ARE CAP VALUES IN PFS WITH ALL PADS IN
C*
      RL0=BETA*RL0*1.0E-09
      C0=ALPHA*C0*1.0E-12

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C1=ALPHA*C1*1.0E-12
C2=ALPHA*C2*1.0E-12
DEL TAC=ALPHA*DEL TAC*1.0E-12
C*
C*****READ ALGORITHM CONSTANTS FROM BFILE
C*
      DO 7 I=1,16
      DO 7 J=1,16
      READ(7,/)KA,LA,AA,BB
      IF(KA.EQ.0)GO TO 8
      A(KA,LA)=AA
      B(KA,LA)=BB
7     CONTINUE
8     DO 9 I=1,16
      DO 9 J=1,16
      READ(7,/)KA,LA,QMUA(KA,LA),QMUB(KA,LA)
      READ(7,/,END=10)QNUA(KA,LA),QNUB(KA,LA)
9     CONTINUE
C*
C*****BEGIN NON LINEAR CALCULATION
C*
C*****FIRST READ MEASURED VALUES WITH
C*      ALL PADS IN
C*
10    WRITE(6,20)
20    FORMAT(1X,'TYPE IN SERIAL NO. ')
      READ/,NS
      IF (NS.EQ.0) GO TO 500
      WRITE(6,23)
23    FORMAT(1X,'LIST ALL OUTPUTS? ')
      READ 25,ANS
25    FORMAT(A6)
      WRITE(6,30)
30    FORMAT(1X,'TYPE IN INITIAL MEASURED SENSITIVITY, '
      /*5X,'DETECTOR VOLTAGE, AND FREQ: ')
      READ/,SM0,VM0,F0
      ERR=ABS(SM0-SD)/SD*100.
      IF(ERR.GT.0.5) GO TO 40
      WRITE(6,/) 'UNIT IS IN SPEC AS IS'
      GO TO 10
C*
C*****CALCULATE VEB/Z12 FOR ALL PADS IN
C*
40    VM0=VM0-VB
      VMMA=VM0+SXX*SM0
      VMMIN=VM0-SXX*SM0
      F0=(F0+ F1 )*1.0E+06
      G=2.*PI*F0
      CS=C1
      CP=C2
      C=1./((1./C0+1./CS+1./CP)
      OE=0(G,YE)
      OW=0(G,YW)
      R=RR(F0)
      RMU0=VMMA*G*CP*CABS(ZDEN(0,G)/ZNUM(0,G))

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      RNU0=VMMIN*G*CP*CABS(ZDEN(RE,G)/ZNUM(RE,G))
C*
C*****CALCULATE ALL REMAINING SENSITIVITIES AND
C*      CHOOSE THE BEST ONE
C*
      ERROR=1.0E+12
      DO 100 K=1,16
      DO 100 L=1,16
      IF(A(K,L).EQ.0) GO TO 100
      F=A(K,L)*F0+B(K,L)
      RMU=QMUA(K,L)*RMU0+QMU(B(K,L)
      RNU=QNUA(K,L)*RNU0+QNUB(K,L)
      G=2.*PI*F
      CS=C1-(K-1)*DEL TAC
      CP=C2-(L-1)*DEL TAC
      C=1./(1./C0+1./CS+1./CP)
      OE=0(G,YE)
      OW=0(G,YW)
      R=RR(F)
      VMAX=RMU/G/CP*CABS(ZNUM(0,G)/ZDEN(0,G))
      VMIN=RNU/G/CP*CABS(ZNUM(RE,G)/ZDEN(RE,G))
      S=ABS(VMAX-VMIN)/SXX/2.
      ETEMP=ABS(S-SD)/SD*100.
      IF(ANS.EQ.'YES') WRITE(6,99)K,L,S,ETEMP,F*1.0E-06-600.
99    FORMAT(2I3,F8.3,F9.1,1X,F6.1)
      IF(ETEMP.GE.ERROR)GO TO 100
      ST=S
      KT=K
      LT=L
      FT=F*1.0E-06-F1
      ERROR=ETEMP
100   CONTINUE
C*
C*****PAD REMOVAL INSTRUCTIONS AND SENSITIVITY PREDICTION
C*
      IF(KT.EQ.1) GO TO 120
      WRITE(6,110) IC(KT)
110   FORMAT(1X,'REMOVE SERIES PADS',1X,14)
120   IF(LT.EQ.1) GO TO 140
      WRITE(6,130) IC(LT)
130   FORMAT(1X,'REMOVE PARALLEL PADS',1X,14)
140   WRITE(6,150) ST,ERROR,FT
150   FORMAT(1X,'PREDICTED SENSITIVITY=',F6.4,1X,'ERROR=',F8.4
      */3X,'FREQUENCY=',F6.1//)
      WRITE(6,160)
160   FORMAT(1X,'RE-MEASURE SENSITIVITY'//1X,'ENTER NEW VALUE:'
      *///)
C*
C*****ENTER NEW SENSITIVITY MEASUREMENT &
C*      BEGIN LINEAR CALCULATION
C*
      READ/,S1
      ERR=ABS(SD-S1)/SD*100.
      IF(ERR.GT.0.5) GO TO 215

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200 WRITE(6,210) ERR
210 FORMAT(1X,'UNIT IS NOW IN SPEC',4X,
*'ERROR=',F6.2,'%'//1X,'NEXT UNIT:')
GO TO 10
215 C1OLD=0
C2OLD=0
C1NEW=-(KT-1)*DEL TAC*1.0E+12
C2NEW=-(LT-1)*DEL TAC*1.0E+12
SOLD=SM0
SNEW=S1
READ(8,/)SD,A1,A2
REWIND 8
LCOUNT=0
MCOUNT=0

C*
C*****START OF POSITIVE ERROR LOOP
C*
220 IF(SNEW.LT.SD) GO TO 280
MCOUNT=0
CC=C2NEW-C2OLD
IF(LCOUNT.NE.0) A2=(SNEW-SOLD)/CC
LCOUNT=LCOUNT+1
B2=SNEW-A2*C2NEW
C2OLD=C2NEW
C2NEW=(SD-B2)/A2
DC=C2NEW-C2OLD
WRITE(6,230) -DC
230 FORMAT(1X,'REMOVE',1X,F8.4,1X,
*'PFS. OF ADDITIONAL PARALLEL CAPACITANCE'/1X,
*'TYPE IN CAPACITANCE ACTUALLY REMOVED:')
READ/,DC
IF(DC.EQ.0) GO TO 320
C2NEW=C2OLD-DC
WRITE(6,240)
240 FORMAT(1X,'ENTER NEW VALUE OF MEASURED SENSITIVITY:')
SOLD=SNEW
READ/,SNEW
ERR=ABS(SNEW-SD)/SD*100.
IF(ERR.LE.0.5) GO TO 200
GO TO 220

C*
C*****START OF NEGATIVE ERROR LOOP
C*
280 IF(SNEW.GT.SD) GO TO 220
LCOUNT=0
CC=C1NEW-C1OLD
IF(MCOUNT.NE.0) A1=(SNEW-SOLD)/CC
MCOUNT=MCOUNT+1
B1=SNEW-A1*C1NEW
C1OLD=C1NEW
C1NEW=(SD-B1)/A1
DC=C1NEW-C1OLD
WRITE(6,290) -DC
290 FORMAT(1X,'REMOVE',1X,F8.4,1X,
*'PFS. OF ADDITIONAL SERIES CAPACITANCE'/1X,

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* 'TYPE IN CAPACITANCE ACTUALLY REMOVED:')
READ/,DC
IF(DC.EQ.0) GO TO 320
CINew=CIOld-DC
WRITE(6,300)
300  FORMAT(IX,'ENTER NEW VALUE OF MEASURED SENSITIVITY:')
     SOLD=SNEW
     READ/,SNEW
     ERR=ABS(SNEW-SD)/SD*100.
     IF(ERR.LE.0.5) GO TO 200
     GO TO 280
320  WRITE(6,340)SNEW,ERR
340  FORMAT(IX,'FINAL SENSITIVITY='F7.4,
*4X,'ERROR=',F6.2,IX,'% '//IX,'NEXT UNIT:')
     GO TO 10
500  WRITE(6,600)
600  FORMAT(IX,'DONE')
     WRITE(6,/)A1,A2
     STOP
     END

```